

# **USDA Agricultural Research Service**

## **Assessment of National Program 106-Aquaculture**

**May, 2013**

### **Executive Summary**

#### **COMPONENT 1. UNDERSTANDING, IMPROVING, AND EFFECTIVELY USING ANIMAL GENETIC AND GENOMIC RESOURCES**

##### **PROBLEM STATEMENT 1A. MAINTAIN AND ENHANCE GENETIC DIVERSITY.**

Yellow perch collected from 17 sampling areas were analyzed using microsatellite approaches. There was significant divergence between fish from the Midwest and fish from the East coast. Initial growth studies compared production characteristics of four of the 17 populations. These studies may provide a template for work with other developing species.

Initial studies have identified 19 polymorphic microsatellites suitable for population analyses of Olympia oysters. This is a first step in designing breeding programs for spat production in hatcheries to be used to restock depleted populations.

While neither yellow perch nor Olympia oysters have the potential to become major industries, the research was considered to be solid. The panel recommends that the work should be continued.

#### **Medium Impact**

##### **PROBLEM STATEMENT 1B. DEVELOP AND IMPLEMENT GENETIC IMPROVEMENT PROGRAMS**

Four projects were used as examples of accomplishments under this problem statement: Atlantic salmon breeding in Maine, cold-water disease resistance breeding for rainbow trout in West Virginia, plant protein tolerance and utilization breeding for rainbow trout in Idaho, and improvement of hybrid (channel x blue) catfish in Mississippi.

The Atlantic salmon work is important since only North American strains can be used in U.S. aquaculture on the East coast. Most of the genetic work has been done in Norway. The rainbow trout cold-water disease breeding program was developed in response to a complex disease problem. Resistant fish produced from this project are being released to industry and collaborations with industry are well developed. This is a high impact effort with strong progress in fundamental science as well as toward meeting industry goals. Developing trout feed based

primarily on plant protein is important and could have significant benefits to the industry by reducing the use of fish meal and bring down feed costs. The emphasis on the blue x channel catfish hybrid is an attempt to produce a fish that may outperform channel catfish. There are still some problems in producing the hybrid catfish in large numbers.

### **Medium-High Impact**

#### **PROBLEM STATEMENT 1C. DEVELOP AND IMPLEMENT GENOMIC TOOLS IN GENETIC IMPROVEMENT PROGRAMS**

The USDA/ARS rainbow trout genomics program in West Virginia has been highly productive and is interacting with industry and university researchers. Stress response genes are being mapped and this activity is providing fundamental information relevant to aquaculture.

The yellow perch program is initiating the development of genomic tools. It will be important to extend those studies to genetic mapping. Efforts with Pacific oysters are focusing on developing predictors for adult performance of families based on juvenile response to stress. This appears to be a promising and novel approach.

The catfish genomics effort is making excellent progress through a consortium effort of university and USDA researchers. Development of homozygous channel catfish through gynogenesis provides valuable genomic material for physical mapping and sequencing studies. Characterization of single nucleotide polymorphisms in both channel and blue catfish is well-advanced.

### **High Impact**

#### **COMPONENT 2. ENHANCING ANIMAL PERFORMANCE, WELL-BEING, AND EFFICIENCY IN DIVERSE PRODUCTION SYSTEMS**

##### **PROBLEM STATEMENT 2A. IMPROVE GROWTH, NUTRIENT UTILIZATION, AND WELL-BEING**

This problem statement contains research programs that are not well integrated. Three elements were outlined in the Action Plan that deal with the basic physiology of growth and feeding, Low stress high health production systems, and transport technologies. It appears that work on fish transport was not conducted during the period under review. At least it was not reported in the retrospective document.

Within this problem area ARS scientists have added scientific insight into a growing body of research on the physiology of growth regulation, various factors that influence the growth hormone axis, and some of the important genes apparently involved in growth regulation in commercially important farmed fish. There is increased understanding about protein metabolism which may ultimately be useful. Much of the work accomplished to date is unique and provides important steps toward unraveling the complex science of growth regulation in farmed fish.

What is not clear is how this research might benefit the domestic aquaculture industry in the short term.

With regard to recirculating water systems, there remain many obstacles for their widespread use. Scientists conducted research that examined the impact of water quality and water exchange rate within a recirculating aquaculture environment on fish performance, health, and well being. USDA/ARS may want to examine alternative species such as yellow perch and sturgeon that might be appropriate for recirculating system.

### **Medium Impact**

#### **PROBLEM STATEMENT 2B. ENHANCE REPRODUCTIVE PERFORMANCE AND REDUCE REPRODUCTIVE LOSSES**

The projects involved controlling maturation in farmed fish, sex determination in yellow perch, spawning and larvae production in pompano, and improving hybrid catfish reproduction. Progress was made in accelerating the puberty of male white bass and producing larger ovaries in adult females. A method of sexing yellow perch through visualization of the external reproductive openings was developed. This is important as female yellow perch grow faster than males.

Controlled spawning and larval production of pompano were achieved. This may open a pathway for development of a commercial industry. Hormone injections to induce ovulation in hybrid catfish and a new holding method for spawners led to improved production and could increase the availability of hybrids to the industry.

### **Medium Impact**

#### **COMPONENT 3. DEFINING NUTRIENT REQUIREMENTS AND NUTRIENT COMPOSITION OF FEEDSTUFFS AND EXPANDING ALTERNATIVE INGREDIENTS**

##### **PROBLEM STATEMENT 3A. DETERMINE NUTRIENT REQUIREMENTS**

Replacement of marine proteins and oils for carnivorous fish has been, as is reducing nitrogen waste. This problem statement addresses the need for knowing nutrient and energy requirements for aquatic species, different life stages, and different culture systems. Benefits are economic because feed is the largest cost of production, and environmental because feed is the source of nutrients which impact the environment. A final element is the impact of feed on reproduction.

Much of the work was conducted with dietary phospholipid requirements for shrimp (*Litopenaeus vannamei*) to provide a baseline for diet development. Reformulated hybrid striped bass diets for summer use were studied with the objective of reducing ammonia production and improving water quality. Fish meal-free plant based diets for trout were successfully developed. A number of studies focused on the digestibility of practical ingredients.

Contributions of the research included how to reduce waste and improve utilization of agricultural byproducts in finfish diets. The program provided solutions for the industry to solve current problems of lack of availability of marine protein for the diets of cultivated fishes. The vitamin premix and all-plant protein diet are available for use in commercial production. This is a model of how to transfer technology properly.

### **High Impact**

#### **PROBLEM STATEMENT 3B. EVALUATE THE NUTRITIONAL VALUE OF ALTERNATIVE SOURCES OF PROTEIN AND LIPID**

New dietary ingredients, particularly plant protein concentrates and byproducts from the biofuel industry, among other novel ingredients, have been characterized and feeds developed from those ingredients. USDA/ARS scientists have shown great leadership, innovation and vision in this field. Specific anticipated products from the action plan include development of a database of digestibility information available on the Web, indices of the nutritional value of ingredients, diets based on ingredient nutrient bioavailability for different species and life stages, new ingredients, and feed processing.

There has been significant progress made on evaluation of alternative protein ingredients and supplementation needs to make diets suitable for production. Demonstration of fish growth on fish meal-free diets is a key outcome. Evaluating health implications of dietary ingredients is a novel approach that has merit. Information generated is already being used by academia, government, and industry.

Technological developments from the program are strong, and the scientific quality is good, however the researchers should work with molecular physiologists and endocrinologists to increase the understanding of nutrition/physiology interactions.

### **High Impact**

#### **COMPONENT 4: IMPROVING HEALTH AND WELFARE OF AQUATIC ANIMALS**

##### **PROBLEM STATEMENT 4A. IDENTIFY GENES INVOLVED IN IMMUNITY AND ANIMALS WITH DISEASE-RESISTANT PHENOTYPES**

The research described in this problem area demonstrated significant progress toward the goals stated in the action plan. In particular, recent progress in identifying immune and genomic responses following vaccination and subsequent challenge has advanced our understanding of the complex interaction between some important bacterial pathogens and their preferred fish hosts. The discoveries are relevant to the needs of the aquaculture industry, however the specific and direct level of benefit to certain segments of the industry (e.g., vaccine application in pond culture of catfish) is difficult to measure or may be hampered by unrealistic industry expectations. The benefits accrued to the US trout industry segments are readily apparent. One way the research could be enhanced would be to elicit more collaborative effort in commercial aquaculture settings.

### **Medium Impact**

#### **PROBLEM STATEMENT 4B: DETECTION AND CONTROL OF PATHOGENS**

Though this area of research should generate much useful and practical information, only a few of the anticipated products were completely developed (*e.g.*, pharmacokinetic studies of florfenicol and efficacy studies of hydrogen peroxide). Generally, this program area should be continued, but may need better coordination or direction to generate a focused plan that will move targeted research and the industry forward in this area. Rapid and potentially field-capable diagnostic tests would be extremely valuable for industry. Some topics (*Weisella* bacteria research and vaccine development, for example), could more appropriately be reported under a different problem statement.

##### **Medium Impact**

#### **PROBLEM STATEMENT 4C. PREVENTION OF DISEASE**

USDA/ARS scientists developed several new live attenuated (modified) vaccines that show promise under experimental conditions and in limited field trials. The diseases for which the vaccines were developed are all economically significant or have the potential to become significant in the catfish industry. Additionally, a vaccine was developed against *Streptococcus iniae* for tilapia. This particular vaccine has been patented and commercialized. USDA/ARS has been responsive to the needs of the catfish and tilapia industry sectors. The field trial results showing improved survival, fish size and feed efficiency following vaccination and compared against presumably infected fish is impressive and could result in adoption by the industry. However, to date there has yet to be widespread utilization of the vaccines to gauge their actual impact.

It would be helpful if there were a close tie with extension and statistical services to provide a foundation for measuring success. It would be valuable to determine how best to incorporate attenuated vaccines into an all-around health management plan.

##### **Medium Impact**

#### **COMPONENT 5. IMPROVING PRODUCTION SYSTEMS, DEVELOPING NEW PRODUCTS, AND ENHANCING PRODUCT QUALITY**

##### **PROBLEM STATEMENT 5A. IMPROVE TECHNOLOGIES FOR RECIRCULATING PRODUCTION SYSTEMS**

The accomplishments report addresses two major trials conducted in replicated systems. The first trial looked at coldwater recycle systems operated at two levels of new water exchange. A second trial added ozone treatment. These are good practical applied studies. However, the Panel did not feel that they would rise to the level of leading edge research or high impact. Also, these results may well not hold up in warmwater recycle systems (which are more widely used than coldwater recycle systems). There is some indication that there were sub-lethal health problems

emerging in the low exchange treatments that had not yet lowered survival, but could affect growth and marketability of the fish. A suggested approach for enhancing the quality and impact of this area would be to focus more on minimizing costs and optimizing production quality rather than achieving minimum water use. One area of this research that is laudable is the proportion of the information generated that was quickly transferred into application in the hands of industry and other researchers.

The evaluation of a low head system for low salinity culture again represents a good practical design. However, the results are not in the form of a replicated trial but more of a Technical Note documenting the production in each of three tanks tied into a common filter system.

### **Medium-Low Impact**

#### **PROBLEM STATEMENT 5B. ENHANCE CONTROL OF POND-BASED ECOSYSTEMS TO MAXIMIZE PRODUCTION AND PRODUCT QUALITY**

The researchers working in this program area have accomplished a number of innovations that are impacting the commercial industry. The research and demonstration efforts should continue, including work on off-flavor control. The research directed toward eliminating off-flavor in catfish ponds has concentrated on a bioremediation approach by developing bacterial strains able to degrade the off-flavor compounds of methyl isoborneol (MIB) and Geosmin. The researchers have been able to isolate strains with these properties and they state that the strains may control off-flavors. However, scale up to being able to utilize, or even evaluate them in ponds remains a large and difficult task.

The most promising area of research deals with the development of the split pond production system. This project has the greatest opportunity to reach the level of high impact. The system allows for greater production per unit of water, land, and feed. There is a need to further document its potential and wider adoption.

### **Medium Impact**

#### **PROBLEM STATEMENT 5C. DEVELOP SHELLFISH SYSTEMS TO MAXIMIZE PRODUCTIVITY AND BIOEFFECTIVENESS**

The research under this problem statement is focused on the Pacific Northwest, where shellfish larvae are commonly reared in hatcheries but juveniles and adults are raised in multiuse public waters. Production is constrained by recent regulatory activity regarding siting.

Of particular significance were the studies showing that bivalve culture would have little impact on the environment outside of the area of the local farm. Detailed special analyses provide a basis for policy decisions. These findings will help with siting new aquaculture operations and the expansion of existing ones.

### **High Impact**

**PROBLEM STATEMENT 5D. IMPROVE PRODUCT QUALITY AND DEVELOP NEW PRODUCTS**

Lack of product consistency is a major concern for some aquatic animal species. Non-invasive testing and detection methods are needed to identify product problems and measure product yield and quality characteristics. Adding value to existing products is needed to meet consumer needs and improve the economic viability of the industry.

Future research in this area should focus on cultured rather than wild caught species and should be integrated with aquaculture feed development. The products that could come out of this research would best be produced in areas with year-round availability of materials.

**Medium Impact**